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Renewable energy sources in the Spanish electricity market: Instruments and effects

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ABSTRACT

The implementation of Directive 2001/77/EC on the promotion of electricity produced from renewable sources sets a target of 22.1% of electricity consumption in the EU in 2010, and establishes various mechanisms that member countries may adopt depending on their needs. This paper analyses these mechanisms, their implementation in Spain by means of RD 661/2007 and the degree of fulfilment of objectives. It concludes with an analysis of the effectiveness of the mechanisms adopted and recommendations on market design.

Contents

Abbreviations: RES, renewable energy sources; EU, European Union; FIT, feed-in tariff; SR, Special Regime; RD, Royal Decree; PFER, Plan for the Promotion of Renewable Energy 2000–2010; CNE, National Energy Commission; TMR, Reference Tariff; PER, Plan for the Promotion of Renewable Energy 2005–2010.

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1. Introduction

Increasing concerns about the climate change resulting from energy production, particularly from electricity generation, and the fast increase in energy consumption have led the use of RES to be current policy concerns in countries all over the world. However, the use of non-renewable energy sources, in particular fossil fuels, will continue to grow in absolute terms but its weight in the technology mix in electricity production is expected to decline. Concerning Europe's renewable energy policy target, phasing-in unprecedented energy efficiency and renewable generation must be paralleled by phasing-out non-sustainable fossil fuel and nuclear power technologies [1]. There are several factors that set RES apart from non-renewable resources.

- *Technological progress, complexity and the availability factor:* The promotion of RES depends mainly on research and development in high-tech. These technologies are not yet cost competitive and in this sense are at a disadvantage in comparison to energy generation using fossil fuels, but after the initial investments have been made renewable energy technologies become more efficient than conventional fuel technologies because of low operating and maintenance costs. Another problem of RES results from their modularity and flexibility. In fact, generating electricity from RES is an inherently discontinuous process. Supplies may be disrupted, leaving the system operator unable to meet demand. This lack of continuity means that a diversified technology mix with fossil fuels is needed.
- *Non-renewable energy sources generate social and environmental costs that are not properly internalised through penalty systems (taxes or fees):* Energy production from non-renewable resources generates negative externalities at both local and global levels. However, these externalities are not yet internalised through taxation and/or charges on energy generated from fossil fuels. This leads to social costs which are not equal to the opportunity cost of electricity generated from these resources. In this regard the EU adopted Directive 2001/77/EC to improve environmental protection and provide sustainable development.[3]
- *The utilisation of non-renewable energy sources continues to be supported by political and economic lobbies, thus hindering the promotion of RES:* An additional problem is related to the existence of economic lobbies which use their political power to maintain a high market share of fossil fuels in electricity generation, which gives companies opportunities to exercise market power.

In this paper we study the regulatory policy for encouraging RES within the liberalised Spanish electricity market. In particular, we study the effect of the Spanish FIT system on the overall electricity market.[4] Some papers [7,8] study the relative efficiency of the different incentive schemes used to promote electricity generation from RES focused on quantities—setting up bidding systems, or quota systems, or on prices—FIT systems. Moreover, there are many papers that study the development and implementation of RES policies in different countries [9–12]. Haas et al [13] provide a historical review of renewable electricity in some EU countries. Sáenz de Miera et al [14] analyze the Spanish case. They argue that although it is generally true that the private costs of renewable electricity generation are above those of conventional electricity, that statement fails to consider the social benefits provided by electricity generation from RES, including environmental and socioeconomic ones. Our paper is related and gives continuity to those by Del Río [15,16]. He provides a complete overview of the last ten years of RES promotion in Spain, focusing on the FIT system. He also evaluates the actual outcomes of successive FIT reforms and their main design elements under a political economy approach. Finally, based on different information sources and empirical data, he suggests that some elements of the RD 2818/1998 should be redesigned. In our paper, we treat with the issue of FIT implementation versus another quantity based-systems and its impact in the oligopolistic Spanish electricity market. We also discuss economic implications of alternative systems and give some policy recommendations.

The rest of the paper is organized as follows. Section 2 briefly reviews the policy and regulatory framework within the EU and how it is transposed in Spain. Section 3 describes the instruments used to promote RES and in particular the instrument implemented by the Spanish regulator and the application of RD 661/2007. Section 4 studies the influence of RES on market performance by providing a descriptive analysis of the Spanish electricity market. Section 5 investigates to what extend instruments to support RES are effective. Section 6 gives conclusions and lists a number of recommendations.

2. Regulatory framework, RES and the electricity market

This section discusses the main changes in European and Spanish legislation regarding the promotion and use of RES in the context of electricity market liberalisation.

2.1. European legislation

The liberalisation of the electricity sector and the reduction of greenhouse gas emissions are two main targets of EU energy policy.[5] Renewable energy policy in the EU started under a research and development programme in 1974. However, the implementation of policies commenced at the Madrid conference in 1994. Since then several directives have been adopted by European Parliaments to meet this target.

Directive 1996/92/EC on common rules for the liberalisation of the internal market for electricity set environmental aims and objectives. A year later, in November 1997, the European Commission proposed doubling the percentage share of RES in gross inland energy consumption within the EU by setting targets of 12% for 2010 [18]. Under the Kyoto Protocol, which was adopted at the same year, the EU committed to reduce greenhouse gas emissions by 8% between 2008 and 2012 with respect to 1990 levels. Similarly, the European Commission's Green Paper [19] proposed the promotion of RES and cogeneration to achieve two objectives: reducing energy dependency and restricting greenhouse gas emissions.

Concerning the promotion of electricity production from RES in the internal electricity market the Directive 2001/77/EC set a target of 22.1% of electricity consumption to be generated from renewable in the EU in 2010. The share of RES in electricity in European countries (EU-15) varies from one country to another. Table 1 reports the shares of renewable in gross electricity consumption in 1997 and 2007, and the target per Member State.

Table 1 shows that the share of renewable in gross electricity consumption is less than 10%. Moreover, the most renewable electricity comes from large hydro plants.[6] Therefore, the future

[3] A study of the evolution of the EU's energy strategy and the impact of those measures in Spain, can be found in Martínez de Alegría et al. [2].

[4] For a general modelling approach of electricity markets, see [3]. A survey of the first wave of the liberalisation and deregulation processes in Europe can be found in [4]. An overview of the effects that privatisation and regulation rules have on electricity markets can be found in [5]. An overview of the main competition and regulatory issues in the Spanish gas and electricity markets, setting them in the broader context of the liberalisation of the European energy market is available in [6].

[5] See for instance the European Commission Green Paper [17]: Ä European strategy for sustainable, competitive and secure energy.

[6] Excluding production from pumped storage plants.

Table 1
Renewable electricity development (with and without large hydro).

	Share of RES in gross electricity consumption (%)			Share of RES (except large hydro) in gross electricity consumption (%)		
	1997 actual	2007 actual	2010 target	1997 actual	2007 actual	2010 target
Austria	67.5	59.8	78.1	10.7	8.4	21.1
Belgium	1.0	4.2	6.0	0.9	3.8	5.8
Denmark	8.9	29.0	29.0	8.7	28.9	29.0
Finland	25.3	26.0	35.0	10.4	10.9	21.7
France	15.2	13.3	21.0	2.2	1.9	8.9
Germany	4.3	15.1	12.5	2.4	11.7	10.3
Greece	8.6	6.8	20.1	0.4	3.0	14.5
Ireland	3.8	9.3	13.2	1.1	7.1	11.7
Italy	16.0	13.7	25.0	4.5	4.6	14.9
Luxembourg	2.0	3.7	5.7	2.1	2.4	5.7
Netherlands	3.5	7.6	12.0	3.5	8.5	12.0
Portugal	38.3	30.1	45.6	4.8	11.7	21.5
Spain	19.7	20.0	29.4	3.6	13.1	17.5
Sweden	49.1	52.1	60.0	5.1	8.0	15.7
UK	1.9	5.1	10.0	0.9	3.8	9.3

Eurostat, IEA and own calculations.

development of renewables is expected to rely mainly on non-large hydro plants due to limited hydro sources. Indeed, in the last few years some countries such as Spain, Denmark, Finland and Germany have already made significant progress on the development of renewables without large hydro plants.

Directive 2003/87/EC of the European Parliament and Council established a scheme for trading greenhouse gas emissions in order to reduce such emissions efficiently in the EU. One year later, Directive 2004/8/EC, establish a transparent common framework for promoting the installation of co-generation plants. This Directive also requires Member States to provide guarantees by showing the origin of generated electricity from high-efficiency co-generation. Finally, Directive 2009/28/EC records an agreement by Member States to set a binding target of 20% of energy consumption to be generated by renewable sources by 2020, taking into account the specific situation of each Member State. Thus, since 2007, the so-called *20/20/20 commitment* has been part of the *green package*, which refers to reaching three objectives: emitting 20% less CO_2 into the atmosphere than in 1990, consuming 20% less energy (energy/GDP) and generating 20% of primary energy from RES by the year 2020. Table 2 below lists the most important European directives on RES in chronological order.

2.2. Spanish legislation

The so-called SR set up a framework for generating electricity through RES. It is regulated in Spain by Act 82/1980 on Energy Conservation. The goals were targeted to achieve improvements in industrial energy efficiency and reduce dependency on external sources following the oil crisis. In the 1990s the National Energy Plan 1991–2000 was established to create incentives for co-generation and energy production from RES. Within that period Act 40/1994 consolidated the SR concept and RD 2366/1994 defined principles concerning electricity production by hydro units, co-generation and other electrical installations supplied by RES. In general, all the Acts and RD passed by Spanish Government on RES follow the EU legislation. Table 3 summarises Spanish legislation on RES in chronological order.

Act 54/1997 (*Ley Del Sector Eléctrico–"Electricity Industry Act"*) established the framework for the process of liberalisation. Competition in generation and end-supply were liberalised while transmission and distribution remained regulated. It establishes an ordinary regime and the above mentioned SR for electricity generation from RES. It also envisages the production of electricity through cogeneration and the treatment, reduction and incineration of waste at facilities with an installed capacity of up to 50 MW. Subsequently, the possibility was given of offering surplus energy to the regulated tariff system (selling directly to distributor) or taking part directly in the production market (directly or through a representative agent). Priority has also been granted for

Table 2
European legislation on RES.

- *Directive 1996/92/EC*, establishing common rules for the internal market in electricity by considering environmental objectives.
- *Directive 2001/77/EC*, on the promotion of electricity produced from RES in the internal electricity market.
- *Directive 2003/54/EC*, provision of information by electricity generators regarding the origin and environmental impact of their products.
- *Directive 2003/87/EC*, establishment of trading system for green gas emission rights and reducing these emissions in an economically efficient way (amending Directive 1996/61/EC).
- *Directive 2004/8/EC*, promotion of high efficient co-generations plants based on the demand in the internal energy markets.
- *Directive 2009/28/EC*, on the promotion of electricity produced from RES amending *Directive 2001/77/EC*.

European Commission.

Table 3
Spanish legislation on RES.

- *Act 82/ 1980*, establishing objectives to improve energy efficiency and reduce energy dependency on external markets.
- *Royal Decree 2366/1994*, on electricity production from hydraulic cogeneration facilities and from RES.
- *Act 54/1997*, differentiating between production by ordinary regime electricity producers and special regime producers.
- *Royal Decree 2818/1998*, establishing specific rules for remuneration for energy production under the special regime.
- *Royal Decree 1663/2000*, creating simplified conditions for the connection of photovoltaic producers to the low-voltage grid.
- *Royal Decree 841/2002*, implementing new regulations on electricity production in the special regime.
- *Royal Decree 1432/2002*, approving the average electricity tariff or reference tariff (TMR).
- *Royal Decree 436/2004*, updating the legal and economic framework of electricity production under the special regime.
- *Royal Legislative Decree 7/2006*, adopting measures on elimination of electricity consumption from co-generation.
- *Royal Decree 616/2007*, regulating electricity production under the special regime, superseding *Royal Decree 436/2004*.
- *Royal Decree 1578/2008*, approving a new mechanism of remuneration for electricity production from photovoltaic solar technology.
- *Royal Legislative Decree 6/2009*, establishing a mechanism for pre-allocation of remuneration under the special regime.

BOE (Spanish Official Journal).

passing electricity generated from RES through the grid, rather than entering directly, as stated in Directive 1996/92/EC. RD 2818/1998 on electrical energy from RES established a mechanism for remuneration under the SR.

The Plan PFER approved by the Government on December 30, 1999 set the growth targets required in each renewable technology to ensure that they accounted for 12% of total energy consumption in Spain by 2010. However, in view of the lack of participation in SR installations under RD 2818/98 and RD-Ley 6/2000, urgent measures have been taken to increase competition with installations with a capacity exceeding 50 MW being compelled to participate in the production market. Meanwhile, the Average Electricity Tariff or Reference Tariff (TMR, hereafter) mechanism was approved in RD 1432/2002. RD 436/2004 refers to establishing a methodological mechanism for updating and systemising the legal and economic framework of the SR. The last update for the SR was introduced by RD 661/2007 which allows producers to sell surplus electricity to distributors in return for considerable compensation in the form of a regulated tariff defined as a percentage of the TMR, or to sell their surplus directly through the daily market or bilateral contracts. In the last case the producer receives the negotiated price plus a premium. The main difference with RD 436/2004 is that sales under the SR are made through the market operator at zero price offers. This incentive and this supplement are also defined generically as a percentage of the TMR. Other significant changes with respect to previous regulations are the following;

- Remuneration under the SR is no longer linked to the TMR and updating tariffs, premiums and allowances depends on economic factors such as the CPI or oil/gas prices. Moreover, remuneration for each type of RES is not homogeneous.[7]
- Reference premium, upper and lower limits are determined for generation from renewables.
- New wind farms must be able to maintain their network connection to avoid brief drop-outs in the network.
- Hybrid systems using biomass and solar thermal installations are acceptable.

The passing of Act 17/2007 to transpose the provisions of Directive 2003/54/EC concerning common rules for the internal electricity market is in line with the above mentioned 20/20/20 targets. Finally, RD 1578/2008 describes the remuneration for electricity production through photovoltaic solar technology, and RD-Ley 6/2009 introduces a registration mechanism to pre-allocate remuneration for SR installations.[8]

3. Instruments and promotion policies for RES

Increasing the share of electricity from RES on the technology mix requires efficient support policies for the promotion and proper regulation of the electricity market. Negative externalities generated by fossil fuels can be avoided by implementing regulations on CO_2 emissions. If it is possible to determine environmental damage the problem can be solved by the introduction of a Pigouvian tax, with the establishment of a competitive equilibrium between the two types of technology.[9] However, the introduction of such taxes causes problems (mainly political) which lead to increases in market prices by adding the environmental cost of fossil fuels. Thus, support for RES is justified from the standpoint of offsetting negative externalities.

3.1. Price-based systems versus quantity-based systems

In this subsection we analyse the relative efficiency of the two main instruments used to promote the use of RES. In EU Member States, and particularly in Spain, the choice of instruments to promote RES is based on efficiency. The concept of efficiency implies that competition between different technologies makes an optimum contribution to systems depending on their marginal cost of generation. Support measures assigned to each technology must be consistent with its cost function. First, they encourage production at minimum possible cost in each period through the available technologies, i.e. *static efficiency*. Secondly, there should be incentives to achieve permanent cost reductions through technological progress, so that ultimately full competition between technologies is reached, i.e. *dynamic efficiency*.

Aside from efficiency issues, RES require capital-intensive processes and, more importantly, are sometimes unable to generate energy through continuous processes. The first barrier can be overcome by implementing support through grants and subsidies to RES and charges on polluting resources. The second aspect is related to modularity. It is a dynamic issue that must be resolved through the following factors: (i) technological advances and their incorporation into the generation of electricity from RES; and (ii) improvements in the processes of electricity transmission and distribution through the improvement of market functioning and the process of liberalisation.

Support systems are divided into three main categories:

- *The feed-in tariff system.* Over the last ten years, FIT systems have become an effective instrument for European countries to generate electricity from RES, especially through wind turbine production. Germany, Denmark and Spain have been the most successful of these countries. Through this system, distributors are required to buy the energy generated by RES at a price determined by the regulator for a certain period of time. Muñoz et al. [21] propose a methodology for harmonization of FIT schemes in the EU based on the main features of the German and Spanish FIT systems. They conclude that a suitable approach should include flexibility mechanisms to update and revise premiums. However, Söderholm [22] refuses some of the economic efficiency issues pointed out by Muñoz et al. by arguing that the approach suggested tends to downplay many of the practical difficulties in assessing the real costs facing investors in renewable electricity and that a harmonized system should primarily address the international spillover effects from renewable electricity promotion in Europe.
- *The competitive bidding system.* Used primarily in the United Kingdom, Ireland and France (the latter until 2000). In this case the regulator keeps a given proportion of the market for the production of RES and develops competition between generators to use these resources. Distributors are required to purchase the

7 For example plants classified in group b.1.1 (solar photovoltaic) receive different premiums depending on whether their power is less than 100 kW, between 100 kW and 10 MW or between 10 MW and 50 MW.

8 RD 1578/2008 was adopted to establish remuneration after the payment deadline indicated in RD 661/2007. This decree classifies two types of photovoltaic solar technology: Type I-located on roof spaces; with power capacity of 20 kW or less (Type 1.1 – 34 c€/kWh) and with power capacity of more than 20 kW (Type 1.2 – 32 c€/kWh); and Type II – located on ground spaces (Type II – 32 c€/kWh). The valid rates and premiums for renewables and wastes are established in the Order ITC/3801/2008.

9 A Pigouvian tax is a class of tax levied on a market activity that generates negative externalities. The tax is intended to correct the market outcome of the activity. In the presence of negative externalities, the social cost of a market activity is not covered by the private cost of the activity. Thus, the market outcome is not efficient and may lead to over-consumption of that product. A Pigouvian tax equal to the negative externality is thought to correct the market outcome back to the efficiency level (see Baumol [20]).

Table 4
Special regime modified by RD 661/2007 and RD 222/2008.

Technologies	RD 661/2007		RD 222/2008	
	Regulated tariff (c€/kWh)	Fixed premium (c€/kWh)	Regulated tariff (c€/kWh)	Fixed premium (c€/kWh)
Solar				
≤100 kW	44.0381	–	45.5134	–
>100 kW and ≤10 kW	41.7500	–	43.1486	–
>10 kW and ≤50 kW	22.9764	–	23.7461	–
Solar thermal elect.	26.9375	25.4000	27.8399	–
Wind				
- Onshore	7.3228	2.9291	7.5681	3.0272
- Offshore	–	–	–	8.7124
Geothermal, ocean, wave	6.8900	3.8444	7.1208	3.9732
Hydro				
≤10 MW	7.800	2.5044	8.0613	2.5883
>10 MW and ≤50 MW	–	2.1044	–	2.1749
Biomass[a]				
- Energy crops	15.889	11.5294	16.4213	12.3795
- Agricultural waste	12.571	8.2114	12.9921	8.9503
- Forestry waste	12.571	8.2114	12.9921	8.9503
- Agricultural industry waste	12.571	8.2114	12.9921	8.9503
- Forestry industry waste	9.2800	4.9214	9.5909	5.5501

CNE and own work.
[a] Plants producing less than 2 MW.

total quantity produced in this part of the market. Sell offers are ranked in order of increasing prices up to the proposed amount.

- *Green certificate system*. This is a quantity-based instrument in which electricity agents (generators and distributors) are obliged to produce or buy a certain quota of energy from RES according to national targets. Green certificates seek to encourage energy production from RES or to increase the proportion of RES in the technology mix. Through this system, a fixed amount of electricity is divided by the total number of certificates and distributed among the generators based on their costs to maintain an efficient allocation. Thus, the marginal costs are equalised between generators. These certificates are allocated to market players to be used in two different ways: (i) selling electricity through the daily market at marginal fixed price, or (ii) selling licenses to operators who must meet a quota in the secondary market for green certificates.

The most significant advantages of green certificates are that they stimulate new ways of using RES generation, in the sense that environmental policy objectives can be easily defined in quantitative terms by introducing particular quotas, and they also encourage cost reductions. Moreover, the secondary market for green certificate transactions gives a double incentive to lower costs. First, electricity produced by RES can be traded through the network at the market price, which tends to be lower due to the introducing of competition. Second, renewable energy producers are under low constant pressure because of competition and creating incentives for potential investors helps manage the costs of both new projects and operational facilities. Finally, green certificate transactions are particularly attractive in an international context, where the transaction possibilities are much higher than at national level, so they are one of the priority instruments of the EU in the medium and long term for developing a Single European Power Market.[10]

[10] The first green certificate system appeared in the Netherlands. Other European countries (including Italy, Belgium and Sweden) subsequently followed suit. Green certificates systems are also currently operating in Wisconsin, New Jersey, New England, the mid-Atlantic states, and Texas.

3.2. *The FIT system in the Spanish electricity market*

It was introduced in 1994 by RD 2366/1994. It consists of a subsidy paid to the producer for each kWh generated from RES. The FIT mechanism in Spain includes both regulated tariff prices and fixed premium prices added to the wholesale market price. Currently, the legal framework for the SR is based on RD 661/2007 (amending RD 436/2004) maintaining the basic principles of previous legislation and making changes in order to comply with Directive 2001/77/EC: at least 29.4% of total electricity consumption should come from renewable sources by 2010. There were two ways to sell electricity generated from RES on the Spanish electricity market:

- Generators can sell directly through the electricity grid without offering on the daily market, and obtain a single regulated tariff rate for each hour of the day. This amount of energy enters the daily market through supply offers made at zero prices.
- Alternatively, generators can sell through the market operator by supplying electricity at the daily market price determined or by bilateral contracts. The final price is the negotiated price plus a FIT to offset the increased cost of generation compared to the market price.

Each producer's choice of tariffs is valid for one year, after that time the producer can decide to maintain the formula or switch to an alternative. Since the passing of RD 2366/1994 several pieces of legislation adopted in regard to the FIT mechanism have been updated by RD-L 222/2008, which establishes compensation rules and methods for electricity distribution. Table 4 summarises the trends in regulated tariffs and fixed premiums for renewable technologies as modified by RD 661/2007 and RD 222/2008.

4. The impact of RES in the Spanish market

In Spain the market regulator, CNE, is in charge of operations under the SR. Since the introduction of RD 661/2007, producers have been able to sell electricity through distributors or representatives under a regulated tariff and in the daily market. Table 5 summarises electricity selling options under the SR and shows that most of the electricity under the SR was sold through the daily market in 2007–2009.

Table 5
Electricity selling options under the special regime.

Options	Distributor under a regulated tariff			Daily market			Representative under a regulated tariff		
Years	2007	2008	2009	2007	2008	2009	2007	2008	2009
Installed capacity (MW)[a]	7606 (8.8%)	6208 (6.8%)	4081 (4.4%)	16,404 (19.1%)	21,520 (23.7%)	21,612 (23.2%)	790 (0.9%)	1743 (1.9%)	5098 (5.5%)
Electricity generation (GWh)[b]	14,243 (5.3%)	12,471 (5.5%)	6296 (2.5%)	42,447 (15.6%)	50,242 (18.1%)	45,834 (18.2%)	1564 (0.5%)	6144 (2.2%)	10,002 (4.0%)

CNE, REE and own work.
[a] Percentage of total installed capacity (MW) (special regime + ordinary regime)
[b] Percentage of total electricity generation (GWh) (special regime + ordinary regime)

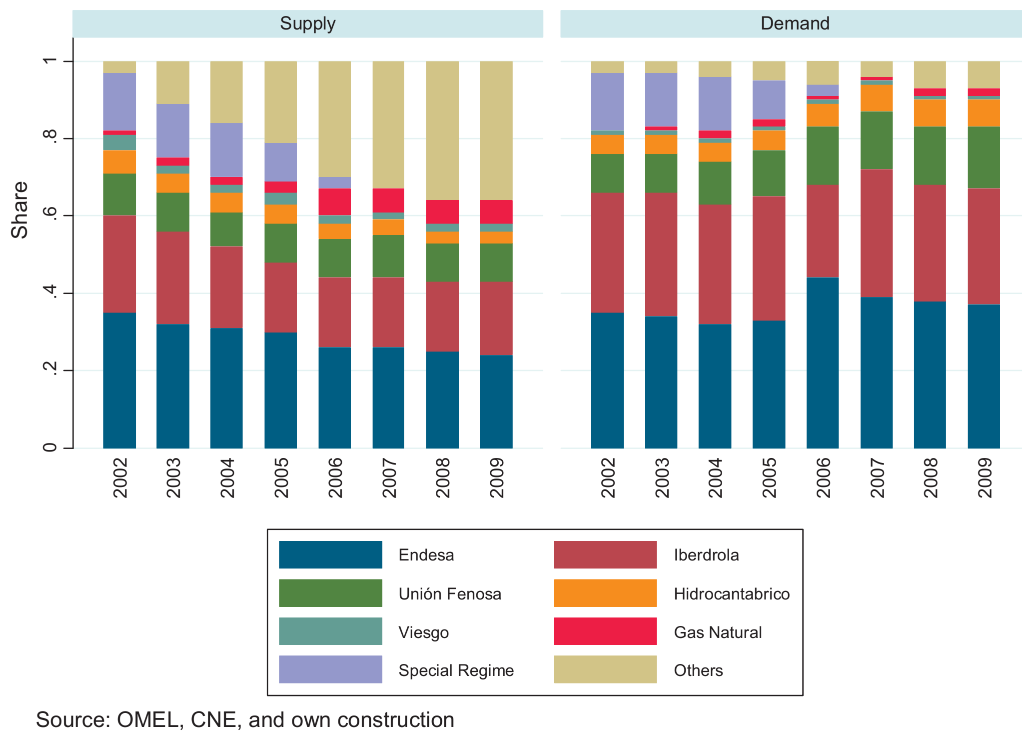

Fig. 1. Market shares by firm.

Fig. 1 summarises the trend in electricity market transactions by companies and the percentage of the total accounted for by the SR since 2002–2009.[11]

Note that liberalisation has been more effective in the case of the two largest companies Endesa and Iberdrola. They have lost market share in generation while still maintaining a significant market share in demand. Also, the development of the SR underwent a sharp decrease from 2005 until 2007. Since 2007 all electricity generated through the SR entered the daily market at zero prices. As will be seen below, the percentage of energy generated by RES has grown considerably in both relative and absolute terms.

Competition in the Spanish electricity market is based on an oligopolistic structure with a small number of players and high levels of concentration, though they have decreased as the liberalisation process has allowed new players to enter the market. The C_2 concentration index fell from 0.70 in 2002 to 0.43 in 2008. At the same time, the market share of electricity generated from RES has been increasing through both the daily and intraday markets. This means that, as explained above, remuneration for electricity generated from RES may be subject to strategic behaviour on the part of large firms that can exert market power. Fig. 2 and Table 6 summarise installed capacity and electricity generation by technology as a proportion of the total for 2002–2008. We distinguish between SR generation from renewable sources and CHP. Further-

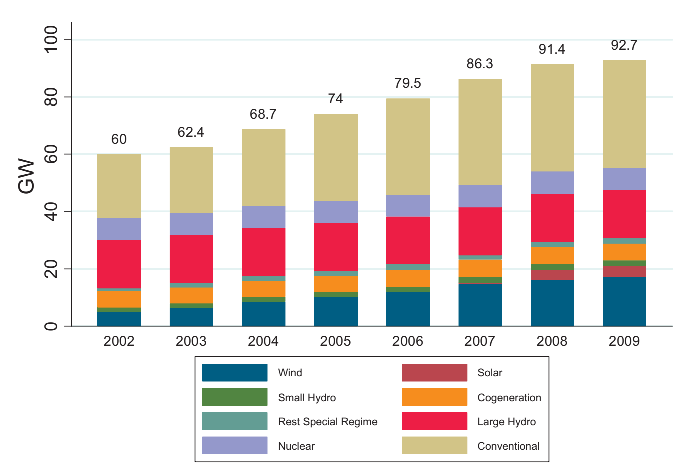

Fig. 2. Installed capacity by technology.

[11] We report energy traded through SR outside the daily market. Notice that since 2007 it is traded through the daily market.

Table 6
Generation by technology (GWh).

Year	Special regime					Ordinary regime			Total[a]
	Wind	Solar	Small hydro	Cogeneration	RSR	Large hydro	Nuclear	Conventional	
2002	9257	–	3901	18,290	4749	22,599	63,016	100,550	213,144
2003	11,720	–	5091	18,995	6336	38,874	61,875	95,267	229,265
2004	15,753	–	4752	19,269	7126	29,777	63,606	113,029	243,631
2005	20,520	–	3820	18,808	8623	19,169	57,539	136,291	253,884
2006	22,736	107	4148	16,782	8410	25,330	60,126	135,417	262,204
2007	27,221	495	4126	17,715	8697	26,352	55,102	142,369	271,636
2008	31,393	2547	4638	21,191	9096	21,428	58,973	139,939	278,301
2009	35,424	5429	4188	17,548	1120	23,236	52,765	116,461	251,305

REE and own work.
[a] Net generation after deduction of in-house consumption.

more, hydroelectric generation is not included in the SR because of its particular characteristics. And within thermoelectric generation we distinguish between nuclear and conventional (using coal as a source of combustion and fuel-gas, known as "combined cycle").

The cumulative growth rate of the energy produced by RES was about 17%, while growth in conventional thermal energy was 8%, which allowed the renewable capacity ratio of total generation to rise from 0.13 in 2002 to 0.26 in 2009. This puts Spain ahead of countries with higher generation capacities in this type of technology and meets the objectives of Directive 2001/71/EC.

Although the use of RES has increased significantly, it has not done so at the same rate for all companies. Table 7 summarises the installed power generating capacity in 2006, before the entry into force of the last major legislation package on the SR and in particular RES, and in 2008, when a number of changes occurred as a result of the new legal framework.

As Table 7 shows, the electricity mix in Spain is generated on the basis of strong growth in RES. This growth comes mainly from wind energy and combined cycles under the SR. In particular Iberdrola (through its division Iberdrola Renovables) is leading this process with strong investment and growth, especially in wind farms. This process resulted in Iberdrola replacing Endesa as the dominant firm in terms of installed capacity in the sector in 2005. More recently, Viesgo, after its merger with EON, has adopted a similar policy of expansion in RES in its generation process.

The observed high concentration levels increase the risk of the two largest generators exercising market power and setting wholesale prices above normal levels. Indeed, the system marginal price set by a marginal plant using fossil-fuel sources is higher than the price set by one using RES. Since the Spanish spot market works via a uniform-price auction, all the energy generated receives payment for the last marginal unit which matches the demand function, which will be posted with the most expensive technology. Thus, the remuneration received by a generator in each time slot from total energy transactions is greater (i) the more bids generators are able to make from RES at zero prices, and (ii) the more expensive the marginal unit of energy that sets the system marginal price is. Thus, unlike the common wisdom is that an increase in energy production from RES should decrease marginal price, it can maintain or even push marginal price up. To illustrate this point, Fig. 3(a) and (b) reports Mega Watts traded by technology and system marginal price for the third Wednesday of May at hour 8 in 2005 and 2010, respectively. It is observed that entering a higher share of renewables in 2010 than in 2005 does not decrease the system marginal price for a similar amount of energy traded.

Thus, other factors should be considered such as price of fuels, market design and strategic interaction between oligopolistic competitors. This creates a rather complex problem of incentives because those resources which are more expensive make prices to go up, as they enter the bidding process at the end. Notice also that firms' supply functions do not accurately reflect the marginal cost of generation when firms exert market power, yielding to abnormal extra profits. In this respect, some studies suggest a reduction in the wholesale price is possible as a result of an increase of RES electricity generation [14]. In particular, they suggest that in the case of wind generation this reduction is greater than the increase in the costs for the consumers arising from the FIT.

Finally, Fig. 4 plots demand coverage for 2002 and 2009 divided by source of generation as a percentage of the total. It is observed that wind energy accounts for a high percentage of the total in 2002.

5. Assessment of instruments in support of RES

There is little consensus among economists about the effects on competition of the incorporation of RES under different regulatory frameworks. Moreover, there is as yet little relevant theoretical and empirical literature. For instance, Palmer and Burtraw [23] find that policies aimed at reducing emissions of greenhouse gases from the electricity sector increase economic costs and electricity prices. However, Clemmer et al. [24] show that such policies can indeed result in lower prices for consumers. Communication of the European Commission [25] on supporting electricity generation from

Table 7
Installed capacity by technology and firm (GW).

Year		EN	IB	UF	HC	GN	VI	Otras	Total
2006	Renewable	0.5	4.0	0.4	1.2	0.3	–	9.4	15.7
	Co-generation	0.3	0.4	–	–	–	–	5.1	5.8
	Hydroelectric	5.3	8.6	1.7	0.4	–	0.7	–	16.7
	Thermoelectric	12.7	11.8	5.3	2.6	2.9	1.7	4.2	41.3
	Total	18.8	24.8	7.4	4.2	3.2	2.4	18.7	79.5
2008	Renewable	2.9	5.5	1	1.4	0.4	0.4	11.9	23.5
	Co-generation	0.3	0.5	0.2	–	–	–	5.1	6.1
	Hydroelectric	5.3	8.6	1.7	0.4	–	0.7	–	16.7
	Thermoelectric	13.1	11.9	7	2.8	3.7	1.7	5.3	44.6
	Total	21.6	26.5	9.9	4.6	4.1	2.8	22.3	91.8

REE, companies websites and own estimates.

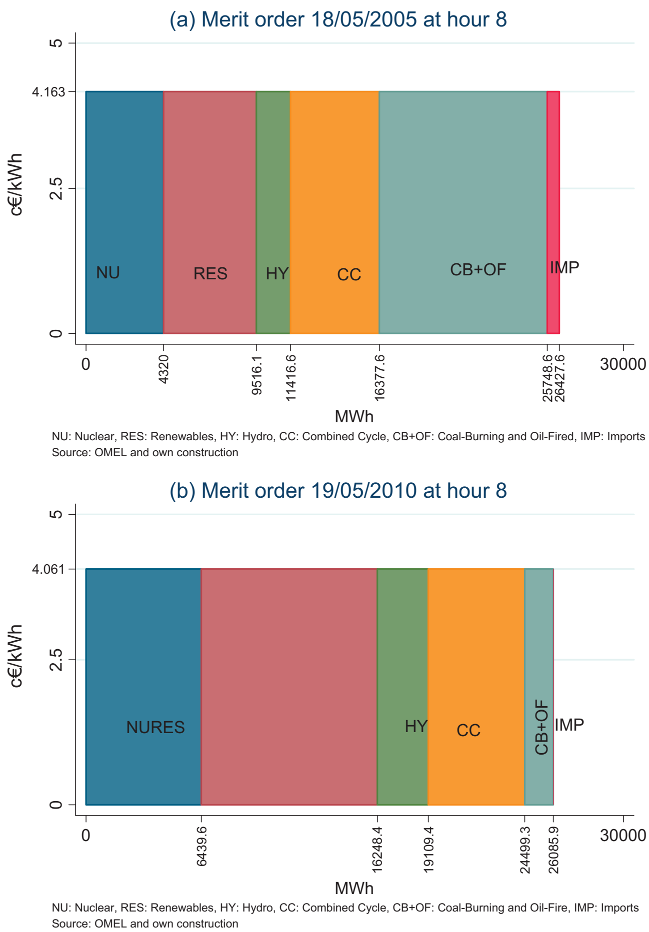

Fig. 3. Merit order on 18/05/2005 and 19/05/2010 at hour 8.

RES concludes that the most effective systems for wind energy promotion are FIT systems. Verbruggen and Lauber [1] also argue that FIT based on an acceptable qualification performs generally better than certificate markets imposing uniform approaches on every diverse reality. However, Menanteau et al. [7] conclude that a system of FIT is more efficient than a bidding system, but highlights the theoretical interest of green certificate.

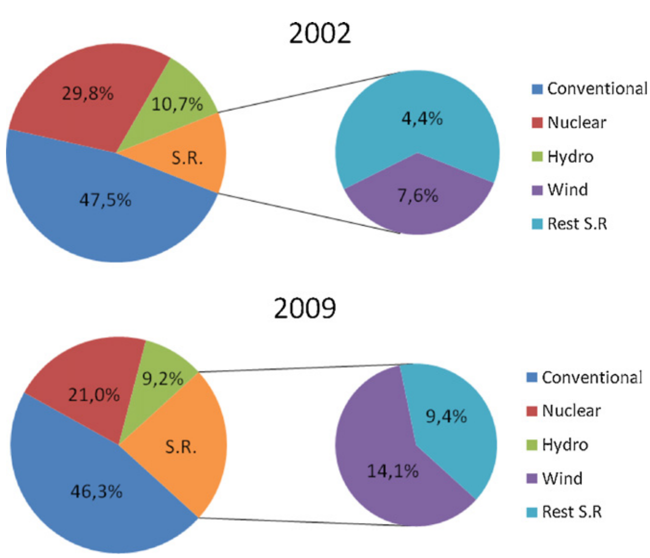

Fig. 4. Demand coverage per technology.

To highlight this controversial issue, we compare the efficiency of a FIT system to a green certificate system based on four aspects: generation incentives, innovation, efficiency and competition.

5.1. Generation incentives

There are significant differences between these two incentive systems in terms of future profitability. The FIT system in Spain has helped to encourage wind energy generation in terms of installed capacity (see Table 7). However, the benefits generated from investments on technologies from RES come from high prices paid to generators. In the absence of market risk, return on investment depends only on the ability of investors to minimize costs. By contrast, green certificates traded through an auction system push prices down due to the pressure of competition. Thus, as profit margins are lower than those generated by fixed or quasi-fixed premiums over time, return on investments is hindered. The influence of risk on expected profits clearly puts tradable green certificates at a disadvantage. In this sense, electricity generation from fossil sources entails lower risks than generation from RES in the absence of a FIT system.

5.2. Encouraging innovation

The main argument for the use of FIT is that they offer a high level of certainty in the profits derived from investment, to both the generating companies and small and medium private (risk averse) producers ensuring a fixed price for each kW/h traded through the network for a certain period of time. As noted above, this certainty can be applied in the short or medium term but in the long-term subsidies may become unsustainable due to cost inefficiencies or incompatibility with a liberalised market and a political system of harmonized energy policies within the EU.

The establishment of dynamic innovation processes depends largely on the learning curve of the dissemination of technologies, but also on R + D + I processes at generator companies. FIT systems give benefits both to investors and producers, but if the subsidy is not adjusted at the same time the system becomes ineffective, as long as technological innovation yields cost reductions. Contrary to this, under the case of tradable green certificates on bidding processes generators should pass cost savings on to end users in order to preserve competition.

5.3. Efficiency

The return on investments in RES technologies offered by FIT systems depend largely on the premiums applied to each technology and other factors including production costs, the availability of other schemes for promoting RES, administrative proceedings and other characteristics at regional and national level. FIT systems have been very effective especially in wind power (Germany, Denmark or Spain). In particular, Perez and Ramos-Real [26] analyses in detail the success of wind energy in Spain until 2007. Apart from wind power, premiums have also had an (albeit much smaller) effect on the promotion of other technologies (photovoltaic, for example). In this sense, the main criticism with respect to premiums is that they are not efficient in both static terms (i.e. able to ensure that electricity is generated and sold at the minimum cost) and dynamic terms (i.e. able to promote innovation). Compared with other promotional schemes, FIT systems generally fail to encourage reductions in the wholesale price of electricity produced from RES. This may be for two reasons:

- Premiums are set by the regulatory authority. However, they usually lack adequate, up-to-date information regarding the cost of production from RES. Therefore, although subsidies depend

individually on each technology, in practice it is very difficult to set a correct premium in each. Moreover, it may be unpopular and politically difficult to reduce premiums over time due to the economic interests of large generators.
- Subsidy schemes are not based on direct competition between those who use RES and those who only use fossil fuels for electricity production.

A recent study by Huber et al. [27] shows that premiums are an efficient instrument in promoting energy from RES only under certain conditions:

- The cost function generated from RES technologies has a lower slope and is predictable with a high probability;
- Premiums decrease over with time in line with the expected learning function of investment costs;
- The time for which a generator receives a subsidy is limited and expected.
- Premiums must decrease as the percentage of total energy from RES increases.

In general, these conditions are difficult to meet, especially the first one. For most RES, accurate knowledge of the cost function in a dynamic context is very limited. In addition, the evidence suggests that the cost function at a given point in time usually has a steeper slope (due to low modularity, and cost increases more than proportionally with increasing output), while the dynamic cost function tends to decrease over time due to technological progress. It is therefore difficult to determine premiums over time and from one technology to another.

5.4. Compatibility with the market and competition

Another major criticism of FIT systems is that they distort competition in the context of a liberalised single market in Europe. In particular, there are three problems.

- Premiums cannot follow the same path as prices that emerge from free competition between generators. This may lead to inefficiencies in energy production from RES.
- A national premium system for generators sets this condition by differentiating between domestic and foreign producers and in return it may generate conflicts of interest in the context of a single electricity market in the EU. European legislation explicitly states that there should be no discrimination between producers from different Member States. If there is discrimination between generators, they may result in financial flows to those Member States that offer high premiums.
- Generators located in areas suitable for the use and exploitation of RES can offer a large production of electricity and receive large amounts in premiums. This puts those located in areas of low achievement at a disadvantage. Compensation mechanisms need to be designed, which at least generates a high administrative cost of monitoring.

Thus, while a FIT system is very simple to implement from an administrative standpoint, it is very expensive in terms of resources. This is true when customers must pay a premium price for electricity produced from RES but also when the government must provide subsidies with premiums through the budget. By contrast, one advantage of systems based on competitive bidding is that the level of subsidies for generation by RES is controlled by the regulator. In this respect, quantity-based systems help to maintain control of expenditure by revealing the cost function of producers. It is possible to obtain a similar result with a bonus scheme by adjusting premiums on technological progress as technologies become increasingly competitive.

Oligopolistic competition models help to show that wholesale prices tend to decrease as production efficiency increases and production costs decrease. Plants which generate electricity from RES (non-hydro) operating at higher production costs are less competitive than conventional thermal generation plants. Therefore, a regulatory framework is required to enable them to grow. However, the premium level set by regulators can actually encourage *excessive* use of renewable. Thus, if a subsidy is too high then it may distort competition when the technical maturity of RES is greater as compared with the cost of fossil fuels.

6. Conclusions and recommendations of regulatory policy

Despite the progress achieved in various RES technologies, the level of development reached is as yet unable to compete with conventional energy sources that use fossil fuels. If technological progress continues and market imperfections are corrected, the two types of technology could compete in the medium-term in the electricity production network. From a theoretical viewpoint, the efficient solution for establishing competition between the two types of generation technology is through a tax or environmental tax to penalize polluting technologies and to subsidize those that generate clean energy. However, this measure must be followed with a system of bonuses and incentives for the use of RES. These bonuses and incentives are based on price, with generators receiving a premium, or on levels, with public authorities setting generation targets that must be achieved by generating companies.

Spain has made significant efforts to meet EU targets for electricity consumption from RES. Technological improvement and the learning process show that in the medium term further increases are possible in the presence of RES in the Spanish electricity system, along with reductions in the problems of the market operator and in the need for generation using fossil fuels. In order to reinforce this goal, it is essential to provide appropriate incentives for agents within a stable regulatory and legal framework to allow technological advances to be taken on board and create the incentives to develop new projects.

Ideally, price- and quantity-based systems should be comparable and both effective in achieving specific objectives in relation to RES. However, in the case of RES the uncertainty associated with availability (which depends heavily on weather conditions and technological development in the foreseeable future) must be taken into account. Consequently, when we evaluate these two instruments we use different criteria to evaluate their efficiency:

Cost control. A quantity-based system is more effective in controlling the costs incurred by the state in carrying out energy policies and allocating quotas for each period. Moreover, it is possible to keep control over installed capacity directly and over the marginal cost of production indirectly. Similar control can be achieved through so-called green certificates. However, under a FIT system the production of RES cannot be anticipated precisely because of the uncertainty about the costs of production. The only solution is to adjust prices according to the performance of each generator, but this would only be possible if they all faced the same production conditions (climate, technical constraints, etc). In practice, this type of control would be difficult to carry out for political and institutional reasons.

Installed capacity. A premium-based system gives much better results than quantity-based systems. In theory, there should not be much difference because FITs provide the same level of output as a quantity-based system (resulting in a comparable capacity). The difference is explained by the greater attractiveness of a fixed-price system, assuring generators that new projects are low risk

investments without a stable incentive system, and with lower transaction costs.

Encouragement of technological change. The incentive to reduce costs is much stronger in a competitive bidding system. Since generators are competing in an oligopolistic market they must incur the lowest possible cost in order to get grants. However, in a FIT scheme there is less incentive to reduce costs and decreases in costs that are not automatically reflected in the incentive system. However, it would be possible to obtain a gradual reduction of costs under a FIT system if it took into account developments in renewable energy technologies.

Overall, a FIT system can be considered as an effective instrument to promote electricity generation from RES in the early stages of development of different sources (wind and photovoltaic in particular) at national level. In the long term, however, such a system can become an obstacle to developing free market competition at the lowest production costs. This is because of the difficulty of financing (especially in stages when green power accounts for a high proportion of the total energy produced) and incomplete information regarding costs. This disadvantage is more notable if the FIT system is fixed, because it distorts competitive price formation, and it is therefore incompatible with the creation of a liberalised market in Europe. In the long term, the best way to promote the use of RES in electricity generation within a liberalised market at European level is to internalize the costs associated with the use of non-renewable resources, for example via taxes or duties, or to introduce a harmonized system of tradable green certificates that includes the environmental benefits of RES versus non-economic evaluations. However, there must be a period of time which will depend on the maturing process of RES as fully competitive, in which the two instruments should be combined.

The degree of fulfillment of objectives such as reducing global warming and ensuring secure, efficient energy supplies adopted by EU leaders in December 2008 depends largely on the evaluation of policies and mechanisms to promote the use of RES in the near future. In the case of Spain the recent Sustainable Economy Act explicitly mentions the promoting of clean energy and the reduction of emissions in Article 3 of its Preliminary Title. Article 98 of the Act explicitly recognizes the need to internalize all the costs and benefits resulting from the use of RES.

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